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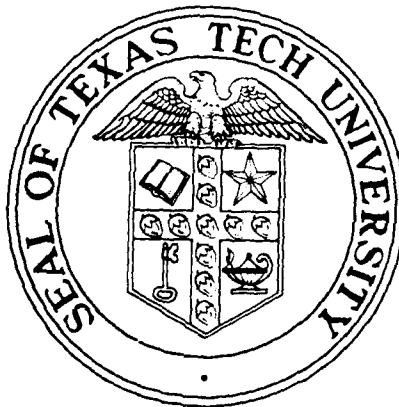
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PLASMA AND SWITCHING LABORATORY
LASER LABORATORY

Department of Electrical Engineering
TEXAS TECH UNIVERSITY

Lubbock, Texas 79409

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ANNUAL REPORT
ON
PULSED POWER RESEARCH COLLOQUIUM

Grant No. AFOSR 78-3675
Project Task No. 2301/A7

July 9, 1981

Submitted by
Plasma and Switching Laboratory
Department of Electrical Engineering
Texas Tech University
Lubbock, Texas 79409

Program Director: M. Kristiansen

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH (AFSC)
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MATTHEW J. KEMER
Chief, Technical Information Division

SUMMARY

The program objectives of this project are: 1) to offer an up-to-date series of lectures on a fast developing, high technology area of present and future importance to the USAF, and 2) to document the basic information, theory, and technology in this field so as to provide a readily available state-of-the-art report for use by various researchers. The lectures are offered approximately every two weeks at AFIT and at AFWL and are aimed at technically trained AF personnel. A Technical Steering Committee, consisting of A.H. Guenther, AFWL; A.K. Hyder, AFOSR; R.E. Fontana, AFIT, Kip Herron, AFAPL; and M. Kristiansen, Texas Tech University, is responsible for the selection of lecture topics. A general format for the published lecture modules has been established along with an appropriate front cover. These lecture modules will later be published in report form. So far, over 30 lectures have been presented and some 12 lecture modules have been printed. Efforts are presently being made to obtain copyright releases from all the authors, with the intent to publish all or part of the material in book form. An offer has also been received to translate and publish the material in Japanese. The attached reprint of a paper presented at the 3rd IEEE International Pulsed Power Conference in June, 1981 describes the program and lists the various lecture topics and speakers along with some planned lecture topics.

MODULAR INSTRUCTIONAL MATERIAL IN PULSED POWER TECHNOLOGY*

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Abstract

A Pulsed Power Lecture Series is being conducted by Texas Tech University for the U.S. Air Force. Modular instructional material for use in this lecture series is being developed. Each module is a self-consistent discussion of some aspect of pulsed power technology. The contents range from the very basic (e.g. basic EM field theory) to advanced, modern topics, such as magnetic switching. The lectures are delivered every two weeks at the Air Force Institute of Technology and the Air Force Weapons Laboratory. The speakers then provide a written text of their lecture, which is edited and published in modular form by Texas Tech University. It is planned to reissue these modules in report or book form at a later date. A total of about 50 modules are planned. Some 30 lectures have been presented, to date, and about 12 modules have been issued. The structure of the program and the use of these modules for teaching graduate and undergraduate courses in pulsed power engineering is discussed.

Introduction

The recent rapid development of pulsed power technology and education has suffered from the lack of modern educational material, such as text books or even organized reference material**. With support from the USAF, we have taken steps to remedy both these shortcomings. The organization of a computerized pulsed power reference source is described in a separate paper at this conference. In this paper we describe the development of modular instructional material in pulsed power technology.

* AFOSR, AFWL, and AFWAL supported.

** The only reasonable text material is "Pulse Generators", Edited by G.N. Glasoe and J.V. Lebacqz, McGraw Hill Book Co. and Dover Publications, Inc., which is over 30 years old! In addition, Dr. J. Sarjeant of LANL is preparing the collection of a set of notes for a handbook on Pulse Power Conditioning.

Module Development

The Department of Electrical Engineering at Texas Tech University has, for the last year, organized a pulsed power lecture series for the USAF. The lectures are offered every other week at the Air Force Institute of Technology at Wright-Patterson Air Force Base in Dayton, Ohio and at the Air Force Weapons Laboratory at Kirtland Air Force Base in Albuquerque, New Mexico. Each lecture lasts for approximately 2½ hours and is tutorial in nature. The lecture topics range from the fundamental to the advanced level (e.g. Basic EM Field Theory or Opening Switch Technology). All lectures so far have been unclassified but it is possible that some future lectures may contain classified material. The lecturers are chosen for their expertise in the lecture topic and come from universities, industry, and national laboratories, and in some special cases from foreign laboratories. Each lecturer prepares a written module covering his lecture topic. These modules are edited and published by Texas Tech University. It is intended that suitable collections of these modules will be republished in report or book form. Many of the modules are presently in use in the undergraduate and graduate pulsed power engineering courses at TTU. The main lecture topics and the lecturers to date are listed below. Beyond the current 35 scheduled topics, more than 15 additional topics are envisioned, as shown. Many of the lecture attendees, especially at the AFWL, are receiving Continuing Education Units (CEU) from TTU.

1. "Introduction to Pulsed Power"
A.H. Guenther - Air Force Weapons Laboratory
2. "Some Basic Concepts and Fundamentals of H.V. Generators"
M. Kristiansen - Texas Tech University
3. "Basic Electromagnetic Field Theory"
M. Kristiansen - Texas Tech University
4. "Circuit and Transmission Line Theory"
M.O. Hagler - Texas Tech University
5. "Electric and Magnetic Properties of Materials"
E.E. Kunhardt - Texas Tech University

6. "Diodes, Electron Beams and Bremsstrahlung"
R.K. Parker and C.A. Kapetanakis -
Naval Research Laboratory
7. "Prime Power"
F.C. Brockhurst - Air Force Institute of Technology
8. "Mechanical Energy Storage and Electromechanical Energy"
W. Weldon - The University of Texas at Austin
9. "Principal Features in Large Capacitor Banks"
E.L. Kemp - Los Alamos National Laboratory
10. "Energy Storage Capacitors"
W.J. Sarjeant - Los Alamos National Laboratory
11. "Marx Generators"
T.H. Martin - Sandia National Laboratories
12. "Other Voltage Multiplier Scheme Variants"
K. Prestwich - Sandia National Laboratories
13. "Inductive Energy Storage"
P. Turchi - R&D Associates
14. "Explosive Generators"
W. Cowan - Sandia National Laboratories
15. "Chemical Energy Storage"
W.S. Bishop - AF Wright Aeronautical Laboratories
16. "Pulsed MHD Generators"
C. Bangerter - STD Research Corporation
17. "Power Conditioning"
G.K. Simcox - Raytheon Company
18. "Transformers"
J. O'Loughlin - Air Force Weapons Laboratory
19. "Power Flow Through Interfaces"
V.P. Vandevender - Sandia National Laboratories
20. "Pulse Forming Net Works"
R. Butcher - Los Alamos National Laboratory
21. "Gas Breakdown"
E.E. Kunhardt - Texas Tech University
22. "Vacuum Switching"
A.S. Gilmour - State University of N.Y./Buffalo
23. "Solid State Switching"
W.M. Portnoy - Texas Tech University
24. "Thyratrons"
D. Turnquist - E G & G
25. "Magnetic Switches and Circuits"
W.C. Nunnally - Los Alamos National Laboratory
26. "Ignitron Switches"
D. Cummings - Physics International Co.
27. "Mechanical Switches"
M. Parsons - Los Alamos National Laboratory
28. "Breakdown in Water"
R. Miller - Maxwell Laboratories, Inc.
29. "Current Interruption-Explosive and Fuse Switching"
I. Vitkovitsky - Naval Research Laboratory
30. "Solid, Liquid, and Gaseous Switches"
J.C. Martin - Aldermaston, Reading, England
31. "Gas Insulated Spark Gaps"
M.O. Hagler and M. Kristiansen - Texas Tech Univ.
32. "Repetitive Switching"
M. Buttram - Sandia National Laboratories
33. "Electro-Magnetic Field Measurements"
C. Baum - Air Force Weapons Laboratory
34. "Opening Switches"
K.H. Schoenbach and M. Kristiansen -
Texas Tech University
35. "Current and Voltage Measurements"
R. Hebner - National Bureau of Standards

Some other planned lecture topics are:

1. Foreign Pulsed Power Technology
2. Modeling Techniques
3. Protective Circuits and Grounding Techniques
4. Control Systems
5. Modulator Design
6. Radar Systems
7. Laser Systems
8. Particle Accelerators
9. Particle Beam Fusion
10. Directed Beam Weapons
11. Nuclear Weapons Effects Simulation
12. Electronic Countermeasures
13. High Beta Magnetic Fusion
14. Coherent Radiation from Relativistic Beams
15. Industrial Applications of Pulsed Power Technology

SUMMARY

The series, so far, appear to have been very successful and the modules, although somewhat late in being issued due to author tardiness, are filling an educational need. Countries, such as Japan and West Germany (FRG), have shown considerable interest in the modules. Various methods for making the modules more generally available are being studied. The program is currently being supported until April, 1982. Beyond that time, it may be necessary to continue a limited lecture series to update some of the modules and to add certain new topics.

Program Director's Publication, 1980-81
Journal and Conference Proceedings Papers

- * 1. "Investigations of a 60 kV, 5 cm Spark Gap for Several Electrode, Insulator and Gas Types", Proc. 3rd IEEE International Pulsed Power Conference, Albuquerque, N.M., June, 1981 (with L.B. Gordon, M.O. Hagler, and H.C. Kirbie).
- * 2. "Space Charge Effects in a Laser-Fiber Optics Triggered Multichannel Spark Gap", Proc. 3rd IEEE International Pulsed Power Conference, Albuquerque, N.M., June, 1981 (with H.C. Harjes, E.E. Kunhardt, L.L. Hatfield, and A.H. Guenther).
- * 3. "Surface Damage of Dielectrics in a Spark Gap", Proc. 3rd IEEE International Pulsed Power Conference, Albuquerque, N.M., June, 1981 (with G.L. Jackson, Kai-Chi Yuan, and L.L. Hatfield).
- * 4. "Report of Workshop on Repetitive Opening Switches, Proc. 3rd IEEE International Pulsed Power Conference, Albuquerque, N.M., June, 1981 (with K.H. Schoenbach, A.H. Guenther, R.J. Harvey, P. Turchi, T.H. Martin, and F.M. Rose).
- * 5. "The Effect of Electron Beam Induced Space Charge on Spark Gap Breakdown", Proc. 3rd IEEE International Pulsed Power Conference, Albuquerque, N.M., June, 1981 (with Y.H. Tzend, E.E. Kunhardt, and A.H. Guenther).
- * 6. "An Optically Controlled Diffuse Discharge Switch", Proc. 3rd IEEE International Pulsed Power Conference, Albuquerque, N.M., June, 1981 (with K.H. Schoenbach, G. Schaefer, E.E. Kunhardt, L.L. Hatfield, and A.H. Guenther).
- * 7. "Modular Instructional Material in Pulsed Power Technology", Proc. 3rd IEEE International Pulsed Power Conference", Albuquerque, N.M., June, 1981 (with A.H. Guenther, J. Ungvarsky, F.C. Brockhurst, R.D. Franklin, A.K. Hyder, and R.L. Gullickson).
- * 8. "Pulsed Power Education at Texas Tech University", Proc. 3rd IEEE International Pulsed Power Conference, Albuquerque, N.M., June, 1981 (with E.E. Kunhardt).
- * 9. "Investigations of Reed Switch Dynamics When Switching Heavy Loads", Proc. 10th International Conference Contact Phenomena, Bucharest, Hungary, Aug. 25-29, 1980 (with B. Miedzinski).
- 10. "Probe Measurements of the Magnetic Field Structure of Fast Wave Toroidal Eigenmodes", Proc. International Symposium on Heating in Toroidal Plasmas, Como, Italy, 1980 (with P.D. Coleman, B.D. Blackwell, and M.O. Hagler).

* Supported by AFOSR, Physics Directorate

- * 11. "An Electron Beam Triggered Spark Gap", IEEE Trans. Plasma Science, PS-8, 181 (1980) (with K. McDonald, M. Newton, E. Kunhardt, and A.H. Guenther).
- 12. "Laser Triggering Through Fiber Optics of A low Jitter Spark Gap", IEEE Trans. Plasma Science, PS-8, 170 (1980) (with H.C. Harjes, L.L. Hatfield, K.H. Schoenbach, and A.H. Guenther).
- 13. "Electro-Optical Surface Flashover Measurement", Applied Physics Letters, 37, 574 (1980) (with J.E. Thompson, J. Lin, and K. Mikkelsen).
- 14. "Investigations of Fast Insulator Surface Flashover in Vacuum", IEEE Transactions on Plasma Science, PS-8, 191 (1980) (with J.E. Thompson, J. Lin, and K. Mikkelsen).
- 15. "Investigations of Various Probe Sheath Materials in the Texas Tech Tokamak", to appear in IEEE Trans. Plasma Science (with P.D. Coleman, B.D. Blackwell, and M.O. Hagler).
- 16. Basic Concepts in Electromagnetic Theory, in Academic American Encyclopedia, Areté Publishing Co., Princeton, N.J. (1980) (with A. Engelhardt).
- * 17. "An Experimental and Numerical Investigation of Laser-Plasma Interactions", to appear in J. Appl. Phys (with R. Druce and M.O. Hagler).

* Supported by AFOSR, Physics Directorate

Interactions

a) Papers Presented

1. "Optical Surface Flashover Measurements for Pulsed and AC Excitations", 9th International Symposium on Discharges and Electrical Insulation in Vacuum, Eindhoven, Netherlands, 1980 (with J.E. Thompson, T.S. Sudarshan, H. Rhinehart, J. Lin, and K. Mikkelsen).

b) Consultative and Advisory Functions

1. Prof. Kristiansen served on the Advisory Committee for the NATO Advanced Study Institute on Breakdown and Discharge in Gases in Les Arcs, France, June 28 - July 10, 1981.
2. Prof. Kristiansen was appointed to the Air Force Scientific Advisory Board.
3. Prof. Kristiansen served as a consultant to NASA on space plasmas on Oct. 8-10, 1980 at Goddard Space Flight Center.
4. Prof. Kristiansen organized a Workshop on Repetitive Opening Switches for the Army Research Office at Tamarron, Colorado, on Jan. 28-30, 1980.

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